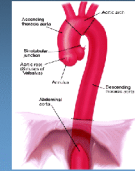
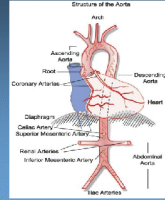
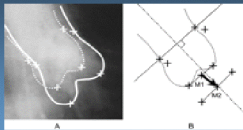
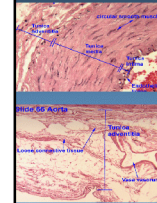
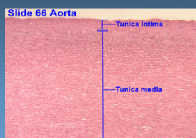
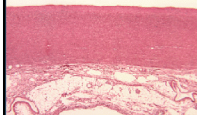
PATOLOGIE DELL'AORTA TORACICA
DI INTERESSE CHIRURGICO
Aldo D. Milano

Anatomia dell'aorta normale
Structure of the Aorta
Arch
Ascending Aorta
Root
Coronary Arteries
Descending Aorta
Heart
Diaphragm
Celiac Artery
Superior Mesenteric Artery
Renal Arteries
Inferior Mesenteric Artery
Abdominal Aorta
Iliac Arteries

Radice aortica
A
B
M1
M2
•Giunzione ventricolo arteriosa
•Parte dei seni di Valsalva
•Giunzione sino tubulare

Aorta normale
Tre strati:
Intima: strato sottile, delicato, ricoperto di endotelio e facilmente traumatizzabile.
Media: dà consistenza all' Ao, composto da strati alternati in maniera spirale di muscolatura liscia e fibre elastiche che consentono il massimo di forza tensile, di distensibilità ed elasticità, che è vitale alla circolazione.
Avventizia:contiene principalmente collagene e contiene gli importanti vasa vasorum, che nutrono la porzione esterna e la gran parte della tunica media.

circular smooth muscle
Tunica adventitia
Tunica media
Tunica intima
Tunica intima
– Strato di endotelio
– Tessuto connettivo basale
Tunica media
– Strati a spirale di cellute muscolari liscie
– Substrato di fibre elastiche
Slide 66 Aorta
Tunica adventitia
Loose connective tissue
Vasa vasorum
•Tunica Avventizia
–Connettivo lasso (collageno)
–Vaso vasorum

Strati dell'aorta
Slide 66 Aorta
Tunica intima
Tunica media
Arteria elastica
La tonaca media comprende la gran parte del
Fibre elastiche interconnesse in maniera circolare.
Il confine tra intima e media non è ben distinto

Aorta normale Vs. vena giugulare
Slide 66 Aorta
Slide 67 Jugular vein
Tunica intima
Tunica adventitia
Tunica media

PATOLOGIE DELL'AORTA TORACICA DI INTERESSE CHIRURGICO
Aneurismi
Falsi aneurismi o pseudoaneurismi
Aterosclerosi diffusa (embolizzazione)
Ulcera aterosclerotica penetrante
Ematoma intramurale
Dissezione aortica
Rottura traumatica dell'aorta

DEFINIZIONI – 1
Aneurisma: dilatazione localizzata dell'aorta (3 strati) con aumento del diametro 50% del normale
Pseudoaneurisma: dilatazione localizzata dell'aorta la cui parete è formata dell'avventizia e da parte della media
Ulcera aterosclerotica penetrante: lesione aterosclerotica che penetra la lamina elastica interna della parete aortica
Ematoma intramurale: stravaso di sangue nella parete aortica senza evidente lesione dell'intima

DEFINIZIONI – 2
Aterosclerosi diffusa: grave aterosclerosi dell'aorta con ateromi sessili, peduncolati o mobili causa di embolizzazione.
Dissezione aortica: stravaso di sangue nella parete aortica (tonaca media) attraverso una lesione intimale con formazione di un falso lume.
Rottura traumatica dell'aorta: lacerazione totale o parziale della parete aortica a seguito di evento traumatico.

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Aneurismi Aorta Toracica

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White males
Black males
White females
Black females
25-34
35-44
45-54
55-64
65-74
75-84
85+
Age
Fig. 1. Death rate per 100,000 from aortic aneurysm

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Malattia spesso dimenticata
Dilemma sociale
Devastante
HOW PATIENTS' PROSPECTS DIFFER
Elective surgery
Medical therapy
Emergency surgery

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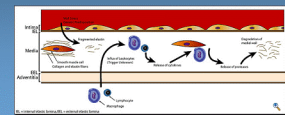
Fattori multipli
•Stress localizzato produce frammentazione della media
•Predisposizione genetica attraverso meccanismi immunologici ignoti
•Attraggono cellule infiammatorie nelle parete aortica che rilasciano citokine e chemochine
•Attivazione di proteasi MMP
•Degradazione della media
•Dilatazione aneurismatica
Intima
IEL
Media
EEL
Adventitia
Fragmented elastin
Smooth muscle cell
Collagen and elastin fibers
Influx of Leukocytes (Trigger Unknown)
Release of cytokines
Release of proteases
Degradation of medial wall
Lymphocyte
Macrophage
IEL = internal elastic lamina, EEL = external elastic lamina

ANEURISMI - 1
DISORDINI GENETICI
– Sindrome di Marfan: alterata sintesi della FIBRILLINA, componente elastico della media
– Sindrome di Ehlers-Danlos: alterata sintesi del collagene (tipo III e IV)
– Aneurisma familiare: aneurisma familiare dell'aorta ascendente con trasmissione autosomica dominante (senza segni di Marfan)

Sindrome di Marfan
Pectus excavatum
arachnodactyly
Dilation of aorta
ADAM
Malattia ereditaria
– Autosomica dominante
– Nel 30% anche casi sporadici
– Mutazioni spontanee
– Affetti 2 per 10,000 persone
Tessuto conettivo
– scheletro
– Sist. Cardiovasc.
– occhi
– cute

ANEURISMI - 2
DEGENERATIVI
– Degenerazione cistica idiopatica della media con frammentazione e perdita del tessuto elastico e delle cellule muscolari
– Aterosclerosi
– Meccanica: associati a valvulopatia ortica: bicuspide, unicuspide, coartazione, fistola

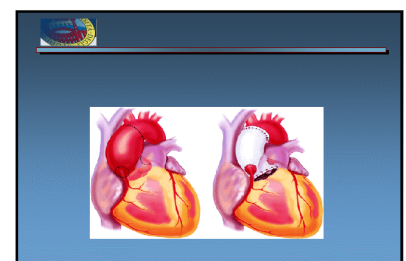
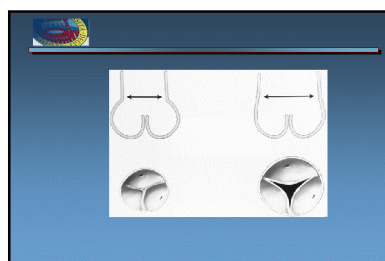
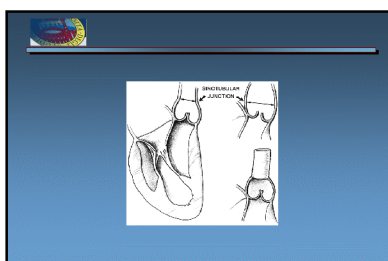
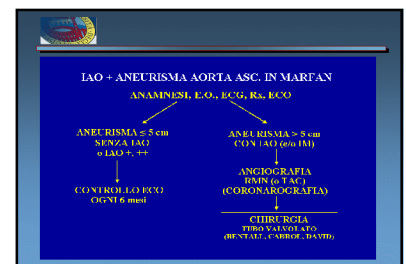
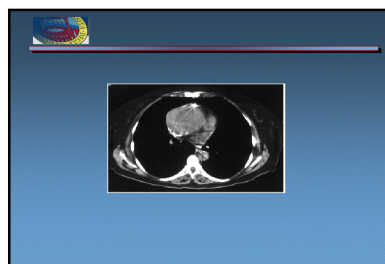
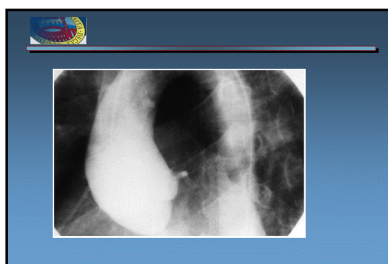
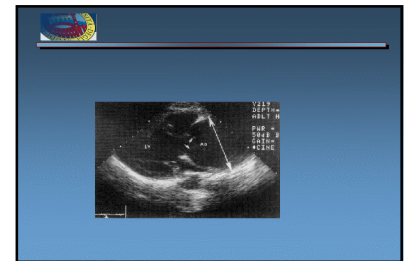
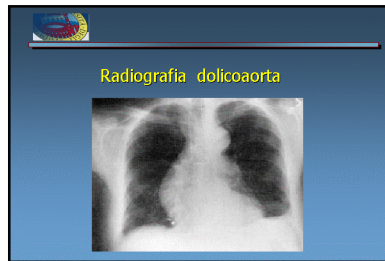
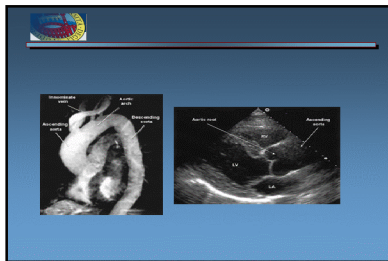
	Maschi	Femmine
Toracica Ascendente	29	27
Toracica Discendente	28	26
Addominale (al tripode)	23	20
Addominale Sottorenale	19	15

Figure 2 **Schematic presentation of the longitudinal parasternal view with four regions where aortic diameters are measured for follow-up analysis in Marfan's syndrome. LV=left ventricle; LA=left atrium; 1=valve annulus; 2=aortic sinuses; 3=sinotubular junction; 4=proximal ascending artery. (Reprinted from Am J Cardiol, Volume 64, Roman MJ, Devereux RB, Kramer, Fox R, O'Loughlin J. Two-dimensional echocardiographic aortic dimensions in children and adults, pp. 507–512 with permission from Excerpta Medica Inc.)**

Table 4 Predicted size of aortic root according to age and body surface area. From Roman et al. [62]

Age (years)	Diameter of aortic root (cm)
<18	1·02+(0·98 × BSA)
18–40	0·97+(1·12 × BSA)
>40	1·92+(0·74 × BSA)

BSA = body surface area (m^2).

Thorax (1968), 23, 338.

A technique for complete replacement of the ascending aorta

HUGH BENTALL AND ANTONY DE BONO

From the Royal Postgraduate Medical School, London, and Hammersmith Hospital

A technique for complete replacement of the aortic valve and ascending aorta in cases of aneurysm of the ascending aorta with aortic valve ectasia is described. The proximal aortic root was too attenuated to afford anchorage to the aortic prosthesis, so this was sutured to the ring of a Starr valve and the prostheses were inserted *en bloc*. The ostia of the coronary arteries were anastomosed to the side of the aortic prosthesis.

Aneurisma aorta ascendente
1. RX Torace
2. ECO
3. TAC
4. RMN
5. ANGIOGRAFIA

Aneurismi aorta ascendente

Risultati

	Mortalità operatoria		Sopravvivenza a distanza	
Patologia	Media	Range	5 anni	10 anni
Marfan	2.5	1-6	78-87	57-73
Ectasia anulo-aortica	3	0-8	65-75	56-75
Degenerativa	3	0-5	71-75	65
Dissezione	10	5-21	56-87	40-65

Kouchoukos NT et al. New Engl J Med 1997; 336: 1876-88

Aneurismi Arco Aortico

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DeBakey ME, Crawford ES, Cooley DA, et al: Successful resection of fusiform aneurysm of the aortic arch with replacement homograft. Surg Gynecol Obstet 1957; 105:657.

Surgery of the aorta
By Michael E. De Bakey,Denton A. Cooley,Oscar Creech Jr.
CIBA Clinical Symposia March/April 1956

Surgery of the aorta
By Michael E. De Bakey,Denton A. Cooley,Oscar Creech Jr.
CIBA Clinical Symposia March/April 1956

Surgery of the aorta
By Michael E. De Bakey,Denton A. Cooley,Oscar Creech Jr.
CIBA Clinical Symposia March/April 1956

Aneurismi aorta ascendente ed arco aortico
DeBakey ME et al.
Surg Gynecol Obstet
1957; 105: 657-64

Surgery of the aorta
By Michael E. De Bakey,Denton A. Cooley,Oscar Creech Jr.
CIBA Clinical Symposia March/April 1956

Surgery of the aorta
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CIBA Clinical Symposia March/April 1956

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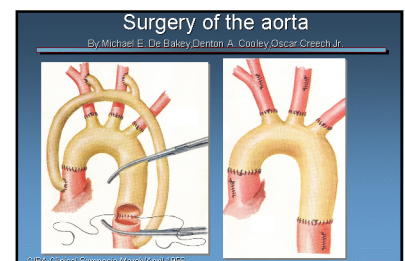
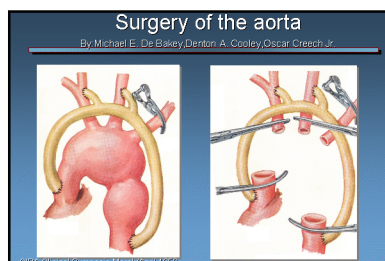
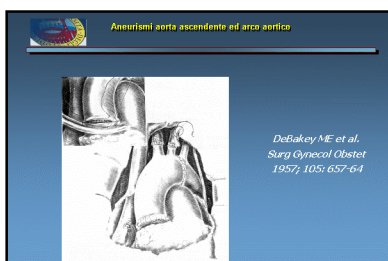
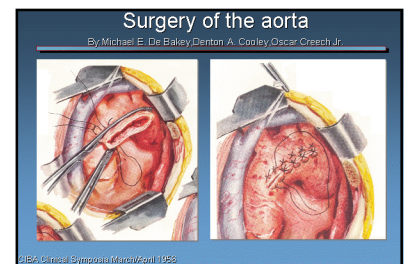
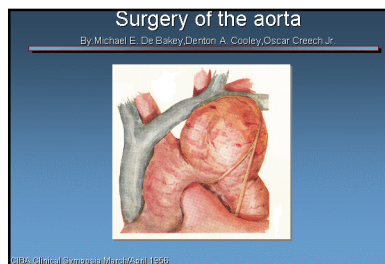
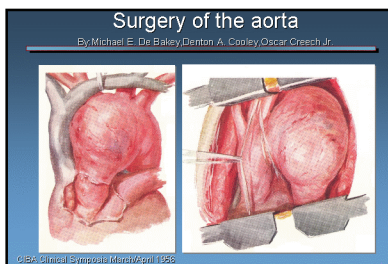
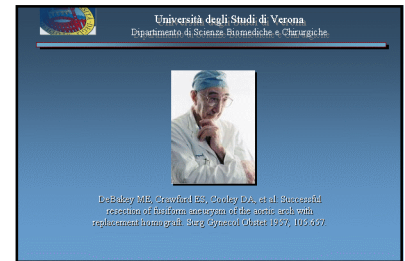
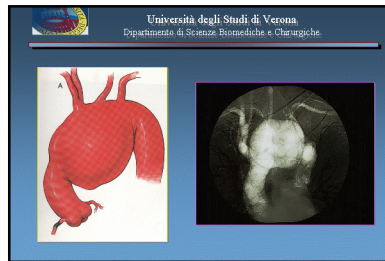
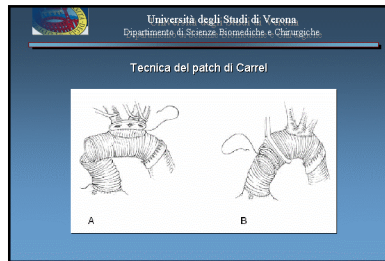
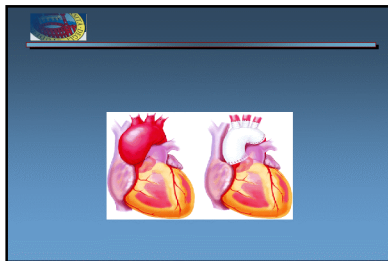
Tecnica del patch di Carrel
A
B

COMPLICANZE
Danno cerebrale
Paresi e Paraplegia
Disfunzione e Insufficienza renale
Disfunzione polmonare
Reintervento

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J. Ennker · J.S. Coselli · T. Treasure
Cerebral Protection in Cerebrovascular and Aortic Surgery
Springer
Among the greatest challenges in cardiovascular surgery today remain operations on aortic arch pathology, supraaortic vessels, and the protection of the brain from hypoxic or ischemic injury during these delicate operations.
Michael E.De Bakey

PROTEZIONE CEREBRALE DURANTE CHIRURGIA DELL'AORTA E DELL'ARCO
IPOTERMIA PROFONDA CON ARRESTO DI CIRCOLO (DHCA)
PERFUSIONE CEREBRALE RETROGRADA (CRP)
PERFUSIONE CEREBRALE SELETTIVA (SCP)ANTEROGRADA SECONDO KAZUI

1) IPOTERMIA PROFONDA E ARRESTO DI CIRCOLO (DHCA)
TECNICA SEMPLICE
CAMPO ESANGUE E LIBERO DA CANNULE
FACILE ISPEZIONE DELL'ANEURISMA
OPEN AORTIC ANASTOMOSIS

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Relazione tra consumo di ossigeno cerebrale e temperatura
TEMPERATURE (°C)

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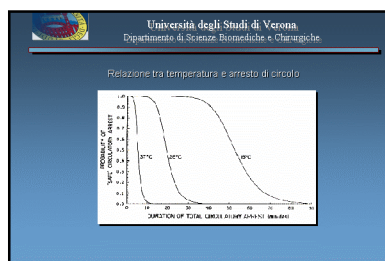
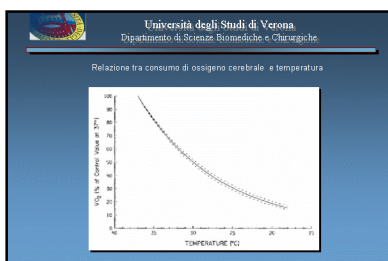
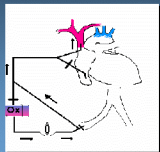
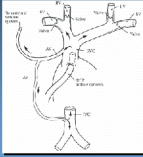
Relazione tra temperatura e arresto di circolo

Protective mechanism of brain during HCA
Safe Duration of HCA
Temp (°C) Cerebral Metabolic Rate (% of baseline) Safe Duration of HCA (min)
37 100 5
30 56 (52-60) 9 (8-10)
25 37 (33-42) 14 (12-15)
20 24 (21-29) 21 (17-24)
15 16 (13-20) 31 (25-38)
10 11 (8-14) 45 (36-62)
Q10 : 2.3 (to 15 °C; 2.05, 15-11.4 °C; 3.5)
(Ann Thorac Surg 1999;67:1895-9)

DHCA
TEMPO LIMITE DI SICUREZZA (TEORICO)
30 MINUTI A 15°C
MC CULLOUGH: Annals Thoracic Surgery 1999; 54:609-16

2) PERFUSIONE CEREBRALE RETROGRADA
WASH OUT EMBOLICO
SUPPORTO NUTRITIVO
UEDA Y. (Osaka Prefectural General Hospital-JAPAN)
Journal Cardiovascular Surgery 1990; 31: 553-8

Università degli Studi di Verona
Dipartimento di Scienze Biomediche e Chirurgiche
Perfusione retrograda

Università degli Studi di Verona
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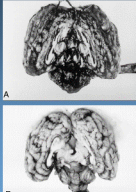
Possibili problemi nella distribuzione del flusso per via retrograda

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Perfusione cerebrale Retrograda
• Ideata per fornire al cervello substrati metabolici e O2 al cervello attraverso la VCS
•Possibile lavaggio retrogrado di emboli gassosi e particolati
• Modesta perfusione capillare
• Disfunzione neurologica
• Raffreddamento cerebrale continuo (distrib. Circolo venoso cereb.)

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Ink-filled vessels on the surface of the brain.
A, Antegrade cerebral perfusion group.
B, Retrograde cerebral perfusion group
Ye J et al. JTCVS 1997;114:660-5

CASISTICA
COSELLI J. (590 Pazienti di cui 290 con DHCA E CRP)
DHCA + CRP
MORTALITA' 3.4 %
DHCA
MORTALITA' 14.8 %

3) PERFUSIONE CEREBRALE SELETTIVA SECONDO KAZUI

TECNICA DI CANNULAZIONE SELETTIVA
TRONCO ANONIMO
ARTERIA CAROTIDE COMUNE SINISTRA

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Perfusione selettiva anterograda

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Malposizione o mobilizzazione di placche durante l'inserimento delle cannule di perfusione
right CCA
right SCA
IA
CATH

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•Anestesia e management perioperatorio
•Pressione intracranica
•Tecnica operatoria
•Flusso cerebrale
•Metabolismo cerebrale

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A
B
C

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循環停止下に先に脳血管を再建する

Interactive CardioVascular and Thoracic Surgery
Interactive Cardiovascular and Thoracic Surgery 3:621-630(2004)
Best evidence topic - Cardiac general
In aortic arch surgery is there any benefit in using antegrade cerebral perfusion or retrograde cerebral perfusion as an adjunct to hypothermic circulatory arrest?
James Barnard, Joel Dunning, Michael Grossebner
Search strategy
Search outcome
408 papers were found
...We conclude that antegrade cerebral perfusion is superior as an adjunct to hypothermic circulatory arrest when compared to retrograde cerebral perfusion or hypothermic circulatory arrest alone

VANTAGGI
• ALLO STATO ATTUALE DELLE CONOSCENZE NON E' POSSIBILE INDICARE UNA METODICA DI PROTEZIONE CEREBRALE VALIDA IN ASSOLUTO PER LA CHIRURGIA DELL'AORTA,
• SICUREZZA DEI TEMPI DI ARRESTO CIRCOLATORIO
• RIDUZIONE DELLE COMPLICANZE COAGULATIVE, POLMONARI E MICROEMBOLICHE LEGATE ALL'IPOTERMIA PROFONDA

MONITORAGGIO NEUROLOGICO
DOPPLER TRANSCRANICO
VALUTAZIONE DEL FLUSSO EMATICO CEREBRALE
EEG, PES
VALUTAZIONE DEL DANNO NEURONALE
SbjVO2, NIRS, CMRO2
VALUTAZIONE DELLO STATO METABOLICO E DELLA OSSIGENAZIONE DEL CERVELLO
L'AUMENTO DEL CONSUMO DI OSSIGENO E' INDICE DI SOFFERENZA CEREBRALE

ELETTROENCEFALOGRAFIA

DOPPLER TRANSCRANICO

NEAR INFRARED SPECTROSCOPY
NIRS

JUGULAR VENOUS OXIMETRY
$S_{BJ}VO_2$

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Monitoraggio neurologico
1. Pressione bilaterale arteria radiale
2. Elettroencefalografia
3. Doppler transcranico bilaterale: flussi e saturazione
60
66

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The recent identification of unique small capillary arteriolar dilatations (SCADs)
in the brain associated with fat emboli raises the possibility that these emboli
not only block small vessels but also release cytotoxic free radicals, which may significantly increase the damage to lipid-rich neurons.
= > Neurocognitive disfunction

Aneurismi arco aortico
Criteri di correzione chirurgica
Diametro ≥ 5.5-6 cm
Segni di allargamento progressivo
Segni di compressione
Spesso associati ad aneurisma aorta ascendente e/o discendente
Coady MA et al. J Thorac Cardiovasc Surg 1997; 113: 476-91

Aneurismi arco aortico
Risultati
Mortalità operatoria Sopravvivenza a distanza
Patologia Media Range 5 anni 10 anni
Degenerativa 6 0-19 - -
Dissezione 12 3.5-24 56 48
Kouchoukos NT et al. New Engl J Med 1997; 336: 1876-88

Aneurismi Aorta Toracica Discendente

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Ascending aorta
Descending aorta
Abdominal aorta

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TAC spirale

Visione chirurgica dell'anatomia aortica attraverso toracotomia
Phrenic nerve
Nasogastric tube
Aorta
Esophagus

Approccio chirurgico agli aneurismi toracici
•Toracotomia sx
•Incisione dell'aneurisma
•Anastomosi prossimale
•Anastomosi di art.intercostali
•Anastomosi distale
•Protezione delle suture(wrapping)

Bypass Cardiopolmonare
Femoro- femorale
Art.ascellare-atrio dx ovena fem.
Solo by pass sinistro
Clampaggio semplice
•Ipotermia profonda e arresto di circolo
•Perfusione anterograda cerebrale
•Perfusione retrograda(rara)

ANEURISMA AORTA TORACICA DISCENDENTE
ASINTOMATICO
ANAMNESI, E.O.
ECG, Rx, ECO T.E.
TAC (o RMN)
CONTROLLO TAC
SINTOMATICO
TAC (o RMN) + CORONAROGRAFIA
TEST RESPIRATORI
CORONAROGRAFIA
DOPPLER CAROTIDEO
INTERVENTO
CONTROINDICAZIONI
CAD NON TRATTABILE
INS. RENALE GRAVE

Aneurismi Aorta Toracica
Discendente Strategia Terapeutica
Se asintomatico < 6.0 cm controllo TAC ogni 6 mesi.
Se asintomatico ma diametro > 6.0 cm e se sintomatico con diametro < 6.0 cm bisogna completare l'iter con: prove respiratorie, Doppler carotideo, coronarografia e aortografia ed eseguire l'intervento.
Nei casi ad eziologia genetica (Sind. Marfan) o valvola Ao bicuspide o pazienti con ipertensione arteriosa non controllata con terapia medica l'indicazione chirurgica nei pazienti asintomatici si pone anche per diametri di < 6 cm.

Aneurismi Toraco-addominali
I
II
III
IV
V
TAAA classification. Type I, from below the LSCA to above the celiac axis, or opposite the SMA and above the renal a. Type II, from below the LSCA and including the infrarenal AA to the level of the aortic bifurcation. Type III, from the 6th ICS tapering to just above the infrarenal AA to the iliac bifurcation. Type IV, from the 12th ICS, tapering to above the iliac bifurcation. Type V, from the 6th ICS, tapering to just above the renal a.
(Safi, et al.)

Approccio chirurgico agli aneurismi toracoaddominali

ANEURISMA TORACO -ADDOMINALE
ANAMNESI, E.O., ECG, Rx, ECO, PROVE RESPIRATORIE, PROVE FUNZIONALI RENALI, DOPPLER CAROTIDEO
CORONAROGRAFIA, PANANGIOGRAFIA, RMN, (o TAC)
< 6 cm
≥ 6 cm
ASINTOMATICO
SINTOMATICO
CONTROLLO PA
CONTROLLO TAC
(o RMN)
ogni 6 mesi
CHIRURGIA
CONTROINDICAZIONI
- CAD DIFFUSA
- STROKE RECENTE

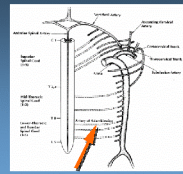
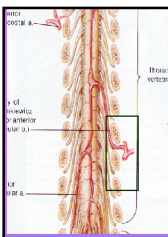
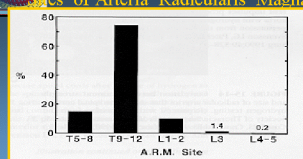
ANEURISMI AORTA TORACICA DISCENDENTE E TORACOADDOMINALI
COMPLICANZE
Danno Neurologico: Paraplegia
Insufficienza Renale
Ischemia intestinale

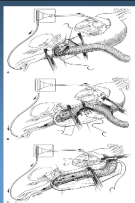
Livelli di paralisi

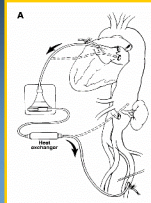
Spinal cord injury:
Incidence of paraplegia and paraparesis after aortic surgery
Svensson (Ann Thor Surg, 1993)
–16% of paraplegia/paraparesis over 1509 pts.
–independent predictors:
aneurysm type
–type I: 15%
–type II: 31%
–type III: 7%
–type IV: 4%
presence of dissection / rupture
aortic cross clamp time
age, renal dysfunction
Griepp (J Thorac cardiovasc Surg, 1996)
–8% pre SSEP
–2% post SSEP

Spinal cord blood supply
Anterior spinal artery
25-30 paia di arterie intercostali
Ciascuna intercostale si divide in Anteriore e Posteriore
Dall'arteria intercostale posteriore origina l'arteria Spinale
Dall'arteria spinale originano l'a.radicolare posteriore e l'a. radicolare anteriore che confluisce nell' a. SPINALE ANTERIORE

Spinal cord blood supply
Single anterior spinal artery (75% of total blood flow)
Two posterolateral spinal arteries (25% of total blood flow)

Spinal cord blood supply
Posterolateral spinal arteries
• They originate from vertebral arteries or posterior inferior cerebellar arteries
• They merge into a poorly defined circumferential anastomotic circulation on the posterior aspect of spinal cord
Arteria vertebrale
Arteria cervicale profonda
Arteria succlavia

Spinal cord blood supply
Anterior spinal artery
• 25-30 pairs of segmental vessels
• these segmental vessels split into 2 rami (ant/post)
• from the posterior rami originate spinal arteries
Posterolateral Spinal Arteries
Posterior Radicular Artery
Spinal Artery
Anterior Spinal Artery
Muscular Branch
Posterior Ramus
Anterior Ramus
Anterior Radicular Artery
Segmental Artery
Aorta

Spinal cord blood supply
Origin of segmental vessels
The arteria radicularis magna (ARM) originates between T8 and L3 (90%) on the left side (80%)

Artery of Adamkiewicz
• Major ant. radicular artery
• From T_7 ~ L_1
• Larger than the other
• Hairpin bend
• Perfuses the spinal cord distal to junction with ASA
• ASA above ARM is smaller in diameter than below the ARM

Sites of Arteria Radicularis Magna
%
80
60
40
20
0
T5-8
T9-12
L1-2
L3
L4-5
1.4
0.2
A.R.M. Site
• Based on this finding, recommend, whenever possible, all intercostal and lumbar arteries from T_6 down to and including L_1 should be reattached
(Lars G. Svensson, 1998)

Strategies to prevent spinal cord ischaemia
1. Riduzione della durata d'ischemia midollare
2. Riduzione del grado di severità dell'ischemia
2. Ripristino del flusso midollare
3. Tecniche per limitare il danno da riperfisione

Reduce duration of ischaemia
• sequential aortic clamping technique (Svensson, Ann Thor Surg, 1998)
– requires atriofemoral partial bypass
– helps to maintain both proximal and distal perfusion

II. Riduzione del grado di ischemia
• Distal aortic perfusion
• Systemic hypothermia including TCA
• CSF drainage (< 7 cmH_2O for 2 days)
• Intrathecal papaverine (before cross clamp)
• Topical and local cooling technique
(Svensson)

LA-fem bypass
A
Heat exchanger
Initial cannulation of LAA and Lt. FA for distal aortic perfusion.
Alternatively, in cases of occlusion or previous aorto-bifemoral bypass surgery, the upper or lower pulmonary vein and the distal thoracic or proximal abdominal aorta are used.
(Safi, et al.)

Incidence of P/P after TAAA repair in comparative studies evaluating LHB

	Extent I			Extent II		
Study	Without LHB	With LHB	p Value	Without LHB	With LHB	p Value
Bavaria, et al*	3/11 (27.3%)	0/14	0.072	2/5 (40.0%)	2/12 (16.7%)	0.330
Safi, et al*	2/30 (6.7%)	1/56 (1.8%)	0.278	9/22 (40.9%)	11/85 (12.9%)	0.003
Present series	9/246 (3.7%)	6/123 (4.9%)	0.576	18/137 (13.1%)	9/189 (4.8%)	0.007

* Both studies have also used CSF drainage since 1992.

(Coselli, et al.)

Calculated safe duration of hypothermic TCA

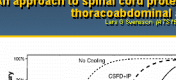
Temperature (°C)	Cerebral Metabolic Rate (% of baseline)	Safe Duration of HCA (min)
37	100	5
30	56 (52 - 60)	9 (8 - 10)
25	37 (33 - 42)	14 (12 - 15)
20	24 (21 - 29)	21 (17 - 24)
15	16 (13 - 20)	31 (25 - 38)
10	11 (8 - 14)	45 (36 - 62)

* Calculations based on assumption that there is a 5-min tolerance for TCA at 37 °C.
Values in parenthesis are 95 % confidence intervals. HCA = hypothermic circulatory arrest

Hypothermic CPB for Spinal Cord Protection : Rationale and Clinical Results
Nicholas T. Kouchoukos, MD, and Chris K. Rokkas, MD
The Heart Center, Missouri Baptist Medical Center, St. Louis, Missouri
(Ann Thorac Surg 1999;67:1940-2)
• 1986.1 - 1998. 4, 114 patients
• EEG monitoring, fem-fem bypass, TEE
• Aorta distal to the diseased segment is isolated circumferentially, the remainder is not dissected.
• Intercostal anastomosis below T6 in 87%
• P/P rate: 2.8%(3/108 pts)

II. Reducing the degree of ischemia
Distal aortic perfusion
Systemic hypothermia including TCA
CSF drainage (< 7 cmH$_2$O for 2 days)
Intrathecal papaverine (before cross clamp)
Topical and local cooling technique
(Svensson)

CSF drainage
A
Cross Clamp
CSF Pressure
DAo Pressure
B
Spinal Cord Protection
① CSF Drain
② DAo Perfusion
③ Core temperature 32° C
A)During ACC, distal Ao. Pr. decreases markedly, causing a reduction in spinal a. perfusion Pr. and a subsequent increase in CSF Pr.
B) LA to LtFA bypass, or distal aortic perfusion, increases distal Ao. Pr. leading to an increase in the spinal a. perfusion Pr., thus increasing blood flow to the spinal cord. The addition of CSFD further decreases CSF Pr. and augments the perfusion of the spinal cord. Moderate hypothermia (32°C) provides additional spinal cord protection.
(Safi, et al.)

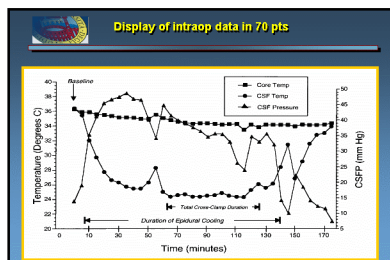
CSF drainage
≤10 mmHg
Catheter insertion for CSFD. Pr. is maintained at or below 10 mmHg
(Safi, et al.)

CSF drainage
Decrease in CSF Pr -- improve spinal bf
Extraction of negative neurotropic factors
Initially, 20 to 50 ml are drained, and additional fluid(as much as 100 ml) is drained throughout op to maintain CSFP at less than 10 mmHg
Cx :
Intraoperative intrathecal bleeding
postoperative headache

An approach to spinal cord protection during descending or thoracoabdominal aortic repairs
Lars G Svensson (ATS 1999;67:1935-6)
No Cooling
CSFD+IP
Active Cooling
Active Cooling and CSFD+IP
Risk of Neurologic Injury
Aortic Clamp Time (min)
LA fem bypass
systemic hypothermia (29 - 30 º C)
CSF drainage
IT papaverine
Various topical and local cooling techniques
Reattachment of intercostals btw T6 - L2

II. Reducing the Degree of Ischemia
Distal aortic perfusion
Systemic hypothermia including TCA
CSF drainage (< 7 cmH2O for 2 days)
Intrathecal papaverine (before cross clamp)
Topical and local cooling technique
(Svensson)

Equipment for epidural cooling
1000cc NS
EDWARDS CARDIAC OUTPUT COMPUTER
OSCILLOSCOPE
TEMP CABLE
INFUSION PUMP
CSF DRAIN PORT
INLINE THERMISTOR
PRESSURE TRANSDUCER
4F EPIDURAL CATHETER
4FR SPINAL CATHETER
ICED CONTAINER
A
B
C
Cambria RP. J Vasc Surg 1994;20:304-310

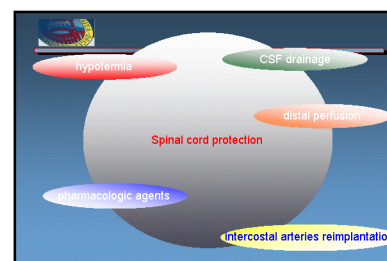
Epidural cooling
Methods and limitation
4 -5 cc/min, iced saline solution
CSF temperature : 23 -25ºC before ACC
CSF Pr increases during infusion, averaging twice the baselines.
Maintain an arbitrary 35 to 40 mmHg gradient btw MAP and CSFP

Display of intraop data in 70 pts
Baseline
Core Temp
CSF Temp
CSF Pressure
Temperature (Degrees C)
CSFP (mm Hg)
Total Cross-Clamp Duration
Duration of Epidural Cooling
Time (minutes)

III. Reestablishment of Spinal Cord Blood Flow
Intercostal anastomosis
To determine which vessels need to be reattached
Arteriography
Hydrogen mapping : hydrogen-rich saline solution
SSEP
MEP
(Lars G. Svensson, 1998)

Intercostal anastomosis
When not feasible
Occlusion by thrombus in the ostia
Calcification of the aortic wall
Rupture or acute aortic dissection
In certain patients with Marfan syndrome
After reattachment, dissection of this patch may occur, resulting in bleeding that needs to be controlled by oversewing
(Lars G. Svensson, 1998)

Reestabilishment of spinal blood flow
post operative care
keep arterial pressure as high as possible
accurate hemostasis
NO vasodilators (especially nitroprusside)
maintain CSF pressure lower than 10 mmHg for 12 hrs after the procedure
corticosteroids
"Interventions for Reversing Postoperative Paraplegia After Thoracic Aortic Reconstruction" Cheung AT (Ann Thor Surg, 2002)

Limit reperfusion injury
free radical scavengers
PEG-SOD (Polyethylene Glycol SuperOxideDismutase)
allopurinol (xanthine oxidase inhibitor)
deferoxamine (free iron chelator)
methylprednisolone (increase membrane stability)
immune system modulation
chloroquine, colchicine (mononuclear phagocytes inhibition)
surface glycoprotein CD18
adenosine
type 1 receptors decrease membrane excitability - limit the damaging influx of calcium
type 2 receptors promote vasodilation, inhibit platelets aggregation and neutrophil activation and subsequent free radical production
excellent results in animal experimental settings

hypotermia
CSF drainage
distal perfusion
Spinal cord protection
pharmacologic agents
intercostal arteries reimplantation

Università degli Studi di Verona
Dipartimento di Scienze Biomediche e Chirurgiche
Uso di stents nell'arco aortico

Correzione degli aneurismi toracici con Endoprotesi

Università degli Studi di Verona
Dipartimento di Scienze Biomediche e Chirurgiche
Trattamento ibrido
Tot.percutaneo
PROXIMAL END OF STENT
DISTAL END OF STENT